Claims

1. A composite quantum dot structure comprising:

a charge carrier confinement region formed of a first material;

a barrier, formed of a second material other than the first material and arranged to confine charge carriers within the charge carrier confinement region; and

a layer of electrically conductive material surrounding said charge carrier confinement region and said barrier.

2. A quantum dot structure according to claim 1, wherein said first material is a semiconductor.

3. A quantum dot structure according to claim 1 or 2, wherein said second material is a semiconductor.

4. A quantum dot structure according to claim 3 when appended to claim 2, wherein the second material has a band gap wider than that of the first material.

5. A quantum dot structure according to claim 1 or 3, wherein said first material is an insulator.

6. A quantum dot structure according to claim 1 or 2, or a quantum dot according to claim 5 when appended to claim 1, wherein said second material is an insulator.

7. A quantum dot structure according to claim 1 or 3, or a quantum dot according to claim 6 when appended to claim 1, wherein said first material is a semi-insulator.

8. A quantum dot structure according to claim 1 or 2, or a quantum dot according to claim 7, when appended to claim 1, wherein said second material is a semi-insulator.

9. A quantum dot structure according to claim 1, wherein said first material is an insulator and said second material is a semi-insulator.

10. A composite quantum dot structure according to any of the preceding claims, wherein said barrier surrounds said charge carrier confinement region.

11. A composite quantum dot structure according to any of the preceding claims, wherein said charge carrier confinement region surrounds said barrier.

12. A quantum dot structure according to claim 10, further comprising a cladding layer located between said barrier and said layer of electrically conductive material.

13. A quantum dot structure according to claim 11, further comprising a cladding layer located between said charge carrier confinement region and said layer of electrically conductive material.

14. A quantum dot structure according to claim 12 or 13, wherein said cladding layer is formed of a semiconducting material

15. A quantum dot structure according to claim 12 or 13, wherein said cladding layer is formed of an insulating material.

16. A quantum dot structure according to claim 12 or 13, wherein said cladding layer is formed of a semi-insulating material.

17. A quantum dot structure according to any of claims 12 to 16, comprising multiple cladding layers, wherein at least two of said cladding layers are formed of different materials.

18. A quantum dot structure according to any of claims 1 to 17, wherein said electrically conductive material is a metal.

19. A quantum dot structure according to claim 18, wherein said metal is a noble metal.

20. A quantum dot structure according to any of the preceding claims, that is substantially spherically symmetrical.

21. A quantum dot structure according to claim 20 when appended to claim 10, wherein an outer radius of the barrier is approximately ten times a radius of the charge carrier confinement region.

22. A quantum dot structure according to claim 20 when appended to claim 10 or when appended to claim 21, wherein the charge carrier confinement region has a radius of 5 nm or less.

23. An optical amplifier comprising one or more quantum dot structures according to any of the preceding claims.

24. A laser comprising one or more quantum dot structures according to any of claims 1 to 23.

25. A light-emitting diode comprising one or more quantum dot structures according to any of claims 1 to 23.

26. An optical switch comprising one or more quantum dot structures according to any of claims 1 to 23.

27. An ensemble of quantum dot structures according to any one of claims 1 to 22, wherein:

at least a first one of said quantum dot structures has a charge carrier confinement region having first dimensions and a barrier having second dimensions;

at least a second one of said quantum dot structures has a charge carrier confinement region having third dimensions and a barrier having fourth

dimensions, the third dimensions being different from the first dimensions and the fourth dimensions being different from the second dimensions; and

the layers of electrically conductive material of said first and second quantum dot structures have substantially the same dimensions.

28. A method of producing a composite quantum dot structure comprising:

providing a charge carrier confinement region formed of a first material;

providing a barrier arranged to confine charge carriers to said charge carrier confinement region, formed of a second material other than the first material; and

providing a layer of electrically conductive material surrounding said charge carrier confinement region and said barrier.

29. A method according to claim 28, wherein said step of providing a barrier comprises surrounding said charge carrier confinement region with said barrier.

30. A method according to claim 29, comprising:

providing at least one cladding layer between said barrier and said layer of electrically conductive material.

31. A method according to claim 28, wherein said step of providing a charge carrier confinement region comprises surrounding said barrier with said charge carrier confinement region.

32. A method according to claim 31, comprising:

providing at least one cladding layer between said charge carrier confinement region and said layer of electrically conductive material.

33. A method according to claim 30 or 32, wherein said step of providing at least one cladding layer comprises providing multiple cladding layers, at least two of said cladding layers being formed of different materials.

34. A method according to claim any of claims 28 to 33, comprising:

incorporating said quantum dot structure in a host material.

35. A method according to claim 29 or 30, comprising:

physically dividing an ensemble of charge carrier confinement regions into a plurality of sub-ensembles; and

reconstituting said ensemble of charge carrier confinement regions;

wherein the steps of providing said barrier and providing said layer of electrically conductive material are performed on the sub-ensembles of charge carrier confinement regions, before said step of reconstituting said plurality of charge carrier confinement regions.

36. A method according to claim 31 or 32, comprising:

physically dividing an ensemble of barriers into a plurality of sub-ensembles; and

reconstituting said ensemble of barriers;

wherein the steps of providing said charge carrier confinement region and providing said layer of electrically conductive material are performed on the sub-ensembles of barriers, before said step of reconstituting said plurality of barriers.

37. A method according to claim 35 or 36, wherein said physical division of said ensemble is performed using a size fractionation process.

38. An ensemble of quantum dot structures comprising:

a first quantum dot structure comprising a charge carrier confinement region formed of a first material and having first dimensions and a barrier formed of a second material and having second dimensions, arranged to confine charge carriers to said charge carrier confinement region, wherein one of said charge carrier confinement region and said barrier surrounds the other of said charge carrier confinement region and said barrier, said first material being different from said second material; and

a second quantum dot structure comprising a charge carrier confinement region formed of the first material and having third dimensions and a barrier formed of the second material and having fourth dimensions, arranged to confine charge carriers to said charge carrier confinement region, , wherein one of said

charge carrier confinement region and said barrier surrounds the other of said charge carrier confinement region and said barrier, said third dimensions being different from said first dimensions and said fourth dimensions being different from said second dimensions;

wherein each of said first and second quantum dot structures comprise an layer of electrically conductive material surrounding said one of said charge carrier confinement region and said barrier, the dimensions of said layers of electrically conductive material of the first and second quantum dot structures being substantially the same.

39. An ensemble according to claim 38, wherein at least one of said first and second quantum dot structures comprises a cladding layer located between the layer of electrically conductive material and either said barrier or said charge carrier confinement region.

40. An optical amplifier comprising an ensemble of quantum dot structures according to claim 38 or 39.

41. A method of producing an ensemble of quantum dot structures comprising:

providing a plurality of charge carrier confinement regions formed of a first material, at least a first one of said charge carrier confinement regions having first dimensions and at least a second one of said charge carrier confinement regions having second dimensions, wherein the first dimensions are not equal to the second dimensions;

providing a plurality of barriers, each one of said barriers being arranged to confine charge carriers to a respective one of said charge carrier confinement regions, the barriers being formed of a second material other than the first material; and

providing a plurality of layers of electrically conductive material;

wherein:

in each quantum dot structure, one of said barrier and said charge carrier confinement regions surrounds the other of said barrier and said charge carrier

confinement region, the layer of electrically conductive material surrounding said one of said barrier and said charge carrier confinement region; and

said first, second, third and fourth dimensions are selected so that the dimensions of said layers of electrically conductive material is substantially the same.

42. A method according to claim 40, wherein at least one of said first and second quantum dot structures comprises at least one cladding layer located between the layer of electrically conductive material and said one of said barrier and said charge carrier confinement region.